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ABSTRACT

This study examined the roles which note-taking method (either pencil and paper or an online computer notepad) and style (verbatim, paraphrasing, etc.) play in retention and depth of processing during computer-delivered instruction. Participants were 112 junior and senior undergraduates from a southern Minnesota university whose major was computer and information science. They were asked to view modules from a tutorial and take notes using either paper and pencil or an online computer notepad. Thirty-two idea units (single complete ideas or blocks of information) were selected from the four modules and used as a basis for assessing notes. A posttest and an exit questionnaire were administered. The study found that: (1) there was a difference in total posttest scores between the control group which took no notes and the treatment group which took notes online. The difference, which supports online notetaking, appeared to be due to the way the control and online notetakers answered the factual-type questions on the posttest; (2) the type of notes taken did not affect the overall retention of information; (3) the method used to take notes and the type of notes taken did not affect the number of idea units recorded by the subjects; (4) a difference in recall scores was found between the verbatim and both the "own-style" and paraphrase notetakers, supporting the verbatim notetakers; and (5) there was a positive correlation between the recall scores and total posttest scores of the subjects. (Contains 31 references.) (Author/AEF)

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**Title:**

# An Assessment of Retention and Depth of Processing Associated with Notetaking Using Traditional Pencil and Paper and an On-line Notepad During Computer-Delivered Instruction

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Abstract

This study examined the role taking notes using either pencil and paper and an on-line computer notepad during computer-delivered instruction have on retention and depth of processing. The results of this study can be summarized as follows: 1. There was a difference in total post-test scores between the control group which took no notes and the treatment group which took notes on-line. The difference, which supported on-line notetaking, appeared to be due to the way the control and on-line notetakers answered the factual-type questions on the post-test; 2. The type of notes taken did not affect the overall retention of information; 3. The method used to take notes and the type of notes taken did not affect the number of idea units recorded by the subjects; 4. A difference in recall scores was found between the verbatim and both the own style and paraphrase notetakers. It supported the verbatim notetakers; 5. There was a positive correlation between the recall scores and total post-test scores of the subjects.

## Introduction

The perception by both educators and students that notetaking is a powerful strategy which enhances recall and learning from lecture and text is supported by research. To date, most notetaking research has centered around the encoding and external storage functions of notetaking as first proposed by Di Vesta and Gray (1972). The encoding hypothesis suggests that notetaking serves to increase the learner's attention during lecture or when reading from text, thereby encouraging learners to integrate and elaborate upon what they hear, see, or read with their prior knowledge. This, in turn, increases the chances of encoding the noted information in long-term memory.

The external storage function, on the other hand, asserts that notes themselves are beneficial only when used as a review tool. In other words, the process of taking notes is not important in recall and retention. It is only the product, the notes themselves, when employed for review, that are important.

In reality, students most likely take notes because of both the encoding and storage functions of notetaking (Hartley & Davies, 1978). In other words, students take notes to maintain a written record of what occurred in lecture or text and later use this record to enhance review. The benefits of the notetaking plus review strategy has been well documented. In studies where notetaking-only groups have been compared to notetaking-plus-review groups and no-notes groups, in general, the notetaking-plus-review groups yielded superior recall (Fisher & Harris, 1973; Carter & Van Matre, 1975; Rickards & Friedman, 1978). In a review of 26 notetaking comparison studies, Ganske (1981) consistently found that students who took notes outperformed those who did not take notes on recall tests when a period of time was provided to review notes. Instead of trying to isolate whether the encoding or storage function is more significant, it may be of more importance to focus on the type of information included in notes which may be indicative of the level of processing used to produce the notes as well as their utility as a review tool.

The movement from behaviorism to cognitivism has significantly influenced the design of instruction delivered via computers. The emphasis has moved from using the computer to deliver simple page turning software to software which encourages learners to actively participate in instruction through lesson sequencing options, embedded questions and answers, predicting and hypothesizing, and customized, specific feedback (Hannafin & Reiber, 1987; Yankelovich & van Dam, 1985; Grubaugh, 1985; Neuwrith, C. M. Kaufer, D., 1987).

Today notetaking applications available on microcomputers range on a continuum from utility-type applications, such as calendars or note-posting options, to sophisticated hypertextual applications used to facilitate recording, organizing and manipulation of the notes.

There are several similarities between computer and text based learning environments. Most computer-delivered instruction and prose offer learners the ability to:

- move to previous prose for additional review and clarification;
- reread passages until they are understood;
- attend to information at a pace determined by the learner;
- use cues such as layouts, formats or heading embedded in the text as visual aids to help determine important information.

Lecture environments on the other hand, require learners to follow at a pace determined by the instructor which, according to Peters (1972), may be at a rate up to 180 words per minute. If visual aids are not used, students in lecture environments must often rely only upon verbal inflections for cueing. The similarities between learning from prose and

from computer-delivered instruction suggest that research methodologies used to assess notetaking from text may be helpful in evaluating the role of notetaking during computer-delivered instruction.

Although the research supporting the utility of notetaking in the prose environment, which is similar to that of the computer-delivered instructional mode, is very positive, there exists a scant amount of research which examines the role of notetaking using either pencil and paper or a computer during computer-delivered instruction itself.

In research related to computers and notetaking, Novellino (1985) compared computerized notetaking and notetaking using pencil and paper in a lecture environment. Subjects were divided into four groups based on notetaking method (computerized and pencil and paper) and gender. Each subject listened to four lectures and recorded notes during each session using one of the methods assigned. After each session a post-test was administered in which the recall of total words, key words, and ideas were assessed. The results indicated that notetaking using pencil and paper yielded greater recall for subjects who were poor typists while notetaking via a microcomputer resulted in greater recall for skilled typists. Significant differences in the time required to complete the lesson favored groups using the microcomputer. No attempt was made to examine the notes themselves to determine if the computerized method facilitated greater assimilation, elaboration, or reorganization on the part of the subjects.

Only one study was located which examined the role of computerized notetaking as an integral part of a lesson delivered via the computer. Wambaugh (1991) assigned undergraduate students to one of these three random treatment conditions during the computer-delivered instruction:

- a control group which was allowed to take no notes;
- a group which created notes using a computer and stored them in a computerized note file;
- a group which captured notes from the instruction by highlighting and copying them to a computer note file.

Wambaugh reported three major findings of this study. First, learners who created their own notes during computer-delivered instruction experienced a significantly higher level of achievement on both immediate and delayed post-tests than learners who captured notes. However, the group that created their own notes did not outperform the control group who took no notes. Second, there was no correlation between either the immediate and delayed post-tests scores and the number of words in the computerized note files created by the two groups of notetakers. Third, there was no correlation between achievement on either the immediate or delayed post-tests and the number of ideas recorded in the subjects' notes which were tested.

Wambaugh contended that no correlations between the immediate and delayed post-test scores, the number of words in the note files, and number of ideas tested may be due to the type of achievement test administered. Both tests required the learner to type responses as a phrase or few words rather than select the correct answer from a list of possible answers. Also, the computer delivery system did not allow learners to look back at previous questions for possible clues.

This study supported the depth of processing hypothesis which contends that the more learners interact with new material in an attempt to make it their own, the more likely it is to be retained in memory. This was accomplished during the study by allowing learners to create their own notes. Unfortunately, Wambaugh did not examine the notes to determine the degree or depth to which students did process the information.

Three observations related to notetaking research in general influenced the design of the present study. First, the duration of most reported notetaking studies has been very limited. Research studies involving notetaking during lecture were often limited to a 50-minute class period or less, while research from prose was often restricted to taking notes from passages that were less than 2,000 words in length. It is questionable whether such research settings represent realistic notetaking situations (Howe, 1974; Hartely & Marshall, 1974).

Second, although Wittrock (1974, 1978) has suggested that benefits are gained from notetaking when learners generate paraphrased notes which incorporate prior knowledge, few research studies have attempted to examine the notes themselves to determine if generative notes are in fact routinely taken by learners. Most research simply assumes that when instructed to take paraphrased notes, subjects produce notes which reflect a deep level of processing (Ganske, 1984; Kiewra, 1987).

Finally, most research related to notetaking has been done utilizing lectures and prose. Although several researchers have indicated the potential benefit of notetaking during computer-delivered instruction (Hannafin, 1989; Kozma, 1987; Jonassen, 1988), little research has been undertaken to assess its merits or to evaluate the use of new procedures available to take notes on-line.

The current study attempted to expand for students, educators, and software designers, the limited research base related to computer-delivered instruction and notetaking by addressing the aforementioned research issues through:

- involving the subjects in notetaking during computer-delivered instruction weekly for a period of four weeks;
- using a computerized notepad as well as pencil and paper as mediums to record notes;

- assessing the generative process of notetaking by evaluating weekly the content of the three types of notes (own style, verbatim, and paraphrase) recorded by subjects using pencil and paper and an on-line notepad.

## Procedures

### Subjects

The sample (N = 112) consisted of junior and senior undergraduates from a southern Minnesota university whose major was computer and information science. Subjects with this major were selected to participate in the study because their discipline required significant time using computer technology. This also assured that all subjects had adequate experience with computers prior to the study, thus minimizing the potential novelty effect often associated with computer-related research.

Students who participated in this study were enrolled in a computer and information science course during the study period. Participation in the study was part of their assigned course work for the quarter. Their performance on the post-test measure did not impact the grade they received in the course.

All students completed a questionnaire prior to the start of the study. Students who indicated they had no prior knowledge of the technical aspects of IBM's AS/400 minicomputer system and had worked extensively with microcomputers and word processing applications were eligible for the study. Based on these criteria, 21 subjects from the original pool of 133 were omitted from the study leaving 112 final participants.

### Materials

Tutorial. This study required participants to view modules from the AS/400 tutorial and take notes from the modules using either pencil and paper or an on-line computer notepad. These modules were selected: Operating System and Architecture Support, Equipment Overview, Control Language Structure, Attachment of Personal Computers and Other Devices. Based on the observations conducted using a similar student sample to view these modules, it was estimated that each module would take approximately 40-60 minutes to view.

A week after the subjects finished the modules, each participant completed an exit questionnaire and took a post-test.

Idea units. Idea units contained in each of the modules viewed by the subjects were determined. An idea unit was defined as a single complete idea or single block of information (Bransford & Johnson, 1972). A total of 32 idea units from the four modules were selected. These idea units served as the basis for assessing notes.

Post-test. The achievement post-test consisted of 40 questions: 22 multiple-choice, 13 fill-in-the blank, and four true/false. The questions included 32 factual and eight synthesis-type questions. The test was completed using paper and pencil. All groups, except the control group who viewed the modules and took no notes, were allowed to review their notes prior to the test. The control group was allowed to mentally review the content of the modules. The reliability of the post-test instrument was .78 as determined by a KR-20 statistical procedure.

Exit questionnaire . This served as a tool to elicit the amount of time subjects spent reviewing prior to the post-test and their preference for text-based or computer-delivered instructional format

### Treatment

Subject groups. The subjects participating in the study were randomly assigned to groups which served to assess the benefits of both the notetaking method (pencil and paper, on-line notepad, or no notes) and the type of notes taken (own style, verbatim, or paraphrased).

Those subjects who were assigned last digits from one to seven participated in the study and their data was used in the analysis of the research. Those subjects who were eliminated from the study due to responses on the pre-study questionnaire were assigned a last digit of eight. This group completed the modules and took the post-test, but their data was not used in any phase of the analysis.

The following list identifies the significance of each of the eight digits used to identify the group assignment of each study participant:

1--served as the control group, only viewed the modules and took no notes;

2--took notes using their own notetaking style with pencil and paper;

3--took verbatim notes with pencil and paper;
4--took paraphrased notes with pencil and paper;
5--took notes using their own notetaking style with the on-line notepad;
6--took verbatim notes with the on-line notepad;
7-took paraphrased notes with the on-line notepad;
8--data not used in the analysis, took notes from modules two and four using any method and type of notes.

For purposes of data analysis, each subject in this study had membership in two groups associated with the method and/or type of notes taken. First, three *notetaking method groups* included subjects who took no notes, notes using pencil and paper, or notes using the on-line notepad. No regard was given to the type of notes taken.

Second, three *note-type groups* included subjects who, regardless of the notetaking method used for notetaking, took verbatim, paraphrased, or notes using their own notetaking style. The three note-type groups, of course, did not contain the control group.

Notetaking methods. Those subjects who, as part of their treatment, took notes on-line, used a computerized notepad which could be opened at any time with a single keystroke. Participants could simultaneously view a module screen and record information on the notepad. The computerized notetaking pad consisted of a scrolling window that had the same formatting, editing, printing, and copy/paste capabilities as a word processor. The notepad was also dynamic; it could be sized and repositioned on the screen at any time. At the end of each module this group was required to print out a copy of their notes for evaluation by the researcher. To discourage uncontrolled review of notes, subjects were asked not to save their notes on electronic media after printing.

Subjects who were required to take notes using pencil and paper supplied these materials for recording notes during each module. They also submitted their notes to the researcher after viewing each module.

Monitoring subject participation. Participants were instructed to complete the review of one module and the related notetaking, if assigned, at one sitting. Weekly reports were obtained from the AS/400 system administrator at the university which listed the name of each subject who accessed the required module during the assigned period and the number of times each module was accessed by the individual. This served to confirm that all research participants, including the control group, did in fact view the assigned modules and all viewing of a module was done in a single session.

Procedure

Training session. Prior to the actual study, each research subject participated in a two-hour training session designed to:

- describe the study and its purpose;
- identify the responsibilities of each participant during the study;
- review the criteria and benefits of good notes regardless of the medium;
- define and provide examples of what is meant by paraphrased, verbatim notes, and individual notetaking styles;
- define the objectives for each module used in the study;
- provide hands-on experience accessing the AS/400 tutorial modules and the on-line notepad.

Four such sessions were conducted in one day. Each training session contained subjects who had been assigned randomly to different treatment conditions. Time was allowed for questions and clarification.

Weekly note evaluation. During the study, all groups viewed a different module each week for four weeks. All subjects, except for the control group, took notes related to the modules using their assigned method and note-type. Because of the accessibility of computers and network efficiency, the weekly viewing/notetaking could be completed by the subjects at any time during the week assigned to that module. After the notes were completed, they were submitted to the researcher for evaluation. In addition, all subjects were required to record and submit their start and stop times for viewing and taking notes from each module.

The weekly evaluation procedure consisted of two tasks. First, each subject's notes were examined to determine if they were produced using the specified note-type (paraphrase, verbatim, or own style) assigned to that subject. Interestingly, during the course of the study, all subjects recorded notes using their assigned types. Second, each subject's notes were examined to determine the number of idea units and to identify which idea units were present. This information, as well as the self-reported time used to view and take notes from each module, was recorded weekly for each subject.

Post-test. One week following the completion of the last module, an exit survey and post-test were administered. Prior to the post-test, the subjects had an open-ended review period. During this period, subjects who had taken notes had their notes returned and were allowed to review them for a minimum of five minutes up to twenty-five minutes. The control group was allowed the same amount of time for mental review. The time used by each subject for review was recorded.

Each post-test was evaluated and the following scores were noted:

- number of correctly answered factual-type post-test questions;
- number of correctly answered synthesis-type post-test questions;
- total number of correctly answered questions;
- recall score which was defined as the correctly answered questions which had corresponding idea units recorded in the subject's notes.

## Results

This study addressed the following research questions:

- does using an on-line computer notetaking device during computer-delivered instruction significantly enhanced learning;
- does taking paraphrased notes during computer-delivered instruction promoted greater recall than verbatim notetaking or notes taken using the subject's own notetaking style;
- are recall scores were affected significantly by the method and/or type of notes taken.

This study was a 2 x 3 factorial design with a control group. The independent variables are the notetaking tool used (notepad or pencil and paper) and note-type (paraphrase, verbatim, or own notetaking style). The control group took no notes while viewing the computer-delivered instruction.

The dependent variables include total post-test score, correctly answered post-test factual and synthesis-type questions, recall score, and number of idea units recorded.

### Results Related to Research Question 1

The results of an ANOVA for notetaking method groups (C, PP, OL) and total post-test score variable a difference between the post-test scores of the group members ($F(2, 109) = 3.17$, $p = .046$) (Table 1).

Table 1
ANOVA for Notetaking Method Groups and Total Post-Test Score Variable

| Source | *df* | *SS* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Between Groups | 2 | 204.55 | 102.27 | 3.17 | .046* |
| Within Groups | 109 | 3517.87 | 32.27 | | |
| Total | 111 | 3722.42 | | | |

*p < .05

Further examination using the Fisher LSD procedure identified a difference between the control group and the on-line group's post-test scores.

A one-way ANOVA revealed no difference between the correctly answered post-test synthesis-type questions of the notetaking method groups (*C, PP, OL*) ($F(2, 109) = 0.36$, $p = .698$).

A one-way ANOVA did reveal a difference between the correctly answered post-test factual-type questions ($F(2, 109) = 3.74$, $p = .027$) (Table 2).

Table 2
ANOVA for Notetaking Method Groups and Post-Test Factual-Type Question Score Variable

| Source | *df* | *SS* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Between Groups | 2 | 166.97 | 83.48 | 3.74 | .027* |
| Within Groups | 109 | 2433.60 | 22.33 | | |
| Total | 111 | 2600.56 | | | |

*p < .05

A follow-up Fisher LSD procedure identified a difference between the way the control group and the on-line group responded to factual-type questions.

Results Related to Research Question 2

Two-way ANOVAs were used to examine whether paraphrased notes promoted greater retention than verbatim notes or notes taken using an individual's own notetaking style.

The total post-test scores, post-test synthesis-type questions scores, and post-test factual-type questions scores of the notetaking method groups (*PP, OL*) and the note-type groups (*O, V, P*) were used to assess the ability of the subjects to retain information.

This procedure showed that there were no differences between their post-test scores (notetaking method groups $p = .150$ and the note-type groups $p = .306$). There was no interaction between the two groups ($p = .670$).

A 2 X 3 ANOVA was used to test for differences between the post-test synthesis and factual-type question scores of the notetaking method groups (*PP, OL*) and the note-type groups (*O, V, P*) . This procedure showed no differences between the mean post-test synthesis-type question scores of the notetaking method groups ($p = .778$) or the note-type groups ($p = .051$). There was no interaction between the two groups ($p = .735$). A two-way ANOVA showed no significant difference between the post-test factual-type question scores of the notetaking method groups ($p = .098$) or the note-type groups ($p = .283$). There was no interaction between the two groups ($p = .651$).

Results Related to Research Question 3

A 2 x 3 ANOVA was used to test for significant differences between the total idea units of the notetaking method groups (*PP, OL*) and the note-type groups (*O, V, P*). This procedure resulted in no significant differences between the mean number of idea units recorded by the notetaking method groups ($p = .663$) and the note-type groups ($p = .052$). There was no significant interaction between them ($p = .879$).

A 2 x 3 ANOVA was used to test for differences between the recall scores of the notetaking method groups (*PP, OL*) and the note-type groups (*O, V, P*) . This procedure indicated that there was a difference between the recall scores of the note-type groups ($p = .002$) but no difference between the recall scores of the notetaking method groups ($p = .064$). There was no interaction between the groups ($p = .616$).

Table 3
Two-Way ANOVA between Notetaking Method Groups and Note-Type Groups for Recall Score Variable

| Source | *df* | *SS* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Explained | 5 | 470.88 | 94.18 | 3.55 | .006 |
| Residual | 87 | 2309.57 | 26.55 | | |
| Total | 92 | 2780.45 | 30.22 | | |

| Source | *df* | *SS* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Notetaking Method | 1 | 93.68 | 93.70 | 3.53 | .064 |
| Note-Type | 2 | 346.18 | 173.09 | 6.52 | .002* |
| NM*NT | 2 | 25.86 | 12.93 | 0.49 | .616 |

* p < .05



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A Fisher LSD procedure was run on the total recall scores of the note-type groups. The results indicate differences between verbatim notetakers and both notetakers who used their own style and paraphrase notetakers.

A Pearson Correlation coefficient between recall scores and post-test scores for all subjects in the study who took notes was .6867 ($p<.01$).

The results of these analyses can be summarized as follows:

1. There was a difference in total post-test scores between the control group which took no notes and the treatment group which took notes on-line. The difference, which supported on-line notetaking, appeared to be due to the way the control and on-line notetakers answered the factual-type questions on the post-test.
2. The type of notes taken did not affect the overall retention of information.
3. The method used to take notes and the type of notes taken did not affect the number of idea units recorded by the subjects.
4. A difference in recall scores was found between the verbatim and both the own style and paraphrase notetakers. It supported the verbatim notetakers.
5. There was a positive correlation between the recall scores and total post-test scores of the subjects.

## Discussion

### Research Question 1

It was predicted that computerized notetaking would elicit greater learning during computer-delivered instruction than taking notes with pencil and paper or taking no notes. Comparisons between the notetaking method groups' total post-test scores, factual-and synthesis-type post-test question responses, and the post-test questions associated with each module were used to assess this hypothesis.

The total post-test score analysis of the notetaking method groups determined a difference did exist between the post-test scores of the on-line and control notetaking methods groups.

Further evaluation also revealed an overall difference in the number of correct responses to factual-type post-test questions by these same two groups, the control and the on-line, while no difference was found between the notetaking member groups' responses to the synthesis-type post-test questions.

Differences in total post-test scores. Two related explanations exist as to why subjects who took notes on-line performed significantly better than those who took no notes.

The first explanation is related to the length of the study. There was a period of five weeks between the time subjects viewed the first tutorial module and the administration of the post-test. Given the duration of the study, it should not be surprising that taking notes and reviewing them prior to testing increased retention more than not taking notes and reviewing only mentally. This finding is consistent with other notetaking research which concluded that taking and reviewing notes was more beneficial to recall than taking no notes and using only a mental review to prepare for evaluation (Kiewra, 1985, 1989; Rickards & Friedman, 1978).

Second, in addition to providing a method to record notes for review, taking notes using the on-line notepad may have provided subjects with a more efficient way to:

- include information in notes;
- organize information in a meaningful manner;
- reduce fatigue which may occur while taking notes using pencil and paper.

These potential advantages, in turn, may have encouraged the on-line subjects to take better, more succinct notes, which may have benefited them during review and testing.

Differences in factual post-test scores. The difference in the total post-test scores of the control and the on-line groups were to a great extent due to the difference in the way group members answered the factual-type, low-level questions rather than the high-level, synthesis-type questions. Two factors may have influenced the subjects' responses to this question type. First, the subjects may have been interacting at a novice level with the subject matter presented in the modules. That is, they may have lacked the subject matter depth and breadth to be effective at integrating prior knowledge with the information presented in the tutorial modules. This could have hampered their efforts to respond to the synthesis-type questions. The subjects may have been more efficient and effective at being able to recall information than integrate information, and, in turn, use this information to solve problems.

Second, eighty percent of the post-test questions were factual. The remaining were synthesis-type questions. Perhaps a more equitable number of both question types would have presented a clearer picture of the relationship, if any,

between the notetaking methods used in the study and the impact of these methods on responses to factual and synthesis-type post-test questions (Jonassen, 1984; Rickards & Friedman, 1978).

Research Question 2

It was predicted that paraphrased notes taken during computer-delivered instruction and reviewed prior to testing would promote greater recall than verbatim notes, or notes created using an individual's own notetaking style. Paraphrased notetaking was anticipated to be a generative activity which encouraged subjects to consciously and intentionally relate new information to existing knowledge, thereby enhancing retention.

To evaluate this hypothesis, the note-type groups' total post-test scores, factual-and synthesis-type post-test scores were examined.

In the note-type groups, this study identified no differences between the total post-test score, factual-type and synthesis-type post-test question responses of the subjects.

These findings are contrary to the other notetaking depth of processing research (Shimmerlik & Nolan, 1976; Bretzing & Kulhavy, 1979; Bretzing & Kulhavy, 1981; Jonassen, 1984). Wittrock's generative learning (1974, 1979) model asserts that learners who actively engage in building associations between that which is known and that which is to be learned create a greater number of associations, which, in turn, enhances recall.

Lack of differences in total post-test and factual-type, and synthesis-type post-test question scores by the note-type groups. Two possible explanations exist for the performance of the note-type groups on the post-test and its component question types. Although the notes for each subject were examined weekly to ensure participants recorded notes that were either paraphrased, verbatim, or recorded using their own style, no determination was made as to the amount or depth of processing done by the learner producing the paraphrased notes. It was assumed by the researcher that additional processing took place. According to Wittrock's generative hypothesis, unless the learner makes use of his or her own knowledge for interpreting incoming information, the process is not generative. Wittrock contends that if the processing is not generative, the associations that are formed will not be as distinct, so less meaning will be generated from the information. It is possible that when paraphrasing notes, this group simply did not engage in processing to the extent suggested by Wittrock's model.

Second, the composition of the post-test, with a large percentage of factual-type questions and limited number of synthesis-type questions, may not have been the optimum format to elicit responses which assess the result of generative learning. A free recall testing format or additional synthesis-type questions may have been more successful at assessing whether paraphrased notetaking promoted more learning than other forms of notetaking (Jonassen, 1984; Rickards & Friedman, 1978).

Research Question 3

It was predicted that information present in notes taken during computer-delivered instruction had a significantly greater chance of being recalled than information not recorded in notes. Previous notetaking research has concluded that when idea units which serve as the basis for post-test questions were present in a subject's notes, the subject had a greater chance of recalling that information than information not recorded in notes (Crawford, 1925b; Howe, 1970; Fisher & Harris, 1973; Kiewra & Fletcher, 1984; Bretzing & Kulhavy, 1981). Both the number of idea units and recall scores calculated using the weekly work submitted by the notetaking method groups and the note-type groups were used to evaluate this hypothesis.

No differences were found in the total number of idea units recorded by the members of the notetaking method groups or the note-type groups.

Differences in the recorded idea units associated with the following modules and groups were found between:

- the verbatim notetakers and both the own style and paraphrase note-type group members in modules one and two;
- the on-line and pencil and paper notetaking methods groups members in module four.

The purpose of examining the recall scores for subjects in this study was to assess what impact recorded idea units had on retention.

Overall, a difference did exist between the total recall scores of the verbatim note-type group and both the own style and paraphrase note-type groups which favored the verbatim group.

Lack of difference in total idea units. Since no overall difference existed in the number of idea units present in the notes of the notetaking method groups or the note-type groups, it may be concluded that neither the methods used to take notes (on-line notepad or pencil and paper) nor the type of notes taken (own style, verbatim, or paraphrase)

influenced the number of idea units recorded in notes. The research participants were apparently able to identify the important ideas as well as record them regardless of the method or type of notes required.

Although there were no differences in the number of idea units among the groups, there were differences between the recall scores of the verbatim note-type group and other group members. Since recall scores were calculated by determining the number of correctly answered post-test questions which also had corresponding idea units present in the subject's notes, one should ask what the verbatim notetakers included in their notes or did in addition to recording the idea units which enhanced their recall. The answer, perhaps, is in the very nature of notes taken, namely the verbatim notes.

Subjects who were asked to take verbatim notes were told during the pre-study training session that the notes should contain exact, precise information about the content of the module. Such structured information in the subjects' notes may have helped them review more effectively for predominantly low-level, factual type questions because their notes had the correct, detailed information for review.

Correlation between recall score and post-test score. The significant positive correlation between recall scores and post-test scores solidifies the importance of recording notes and having them available for review.

## Recommendations for Further Research

Several of these questions suggest opportunities for future research. They include

1. What factors were responsible for the overall success of the on-line notetaking group? Were these factors cognitively based or were they associated with the attributes of the on-line notepad which allowed the user to easily record, organize, and read information once it has been recorded?

2. Is there one type of notes (i.e. verbatim, paraphrase, or own style) which is better suited for low-level or high-level items? Is the success of the verbatim notetakers on tests of factual detail due to the process of recording information or due to the completeness of the notes which were later used in the review process?

3. What level of computer expertise must be reached before an on-line notepad can be used easily and confidently by the learner? Does a subject's attitude towards new technologies and their use of such technologies affect the learner's desire to use an on-line notepad for notetaking?

4. At what age can a learner effectively take notes and use them as a useful learning strategy, a resource for study and review? At what age and subject-level mastery are learners capable of generating paraphrased notes? This study assumed that the subjects knew when material should be included in notes. What strategies could be incorporated into computer-delivered instruction to alert younger learners when important information, which perhaps should be included in their notes, is presented ?

5. Does the medium used to deliver instruction affect the success of the notetaking method? For example, assume that the content of the tutorial modules used in this study was available on paper as well as on the computer. Will on-line notetaking produce similar results using the paper format as it did using the computer?

6. By allowing subjects to both take and review their own notes, this research supported both the process and product functions of notetaking during computer-delivered instruction. Does taking notes either on-line or with paper and pencil during computer-delivered instruction benefit students who are allowed to only record notes without the opportunity to review them?

7. Do notetakers outperform non-notetakers when the number of modules and the time required to complete them is either increased or decreased? Does a delay period between viewing modules significantly affect retention?

8. Given that an on-line notepad is required for on-line notetaking, are there elements associated with the on-line notepad's interface design which could be modified to encourage use even by novice computer users?

9. There has been no research done which assesses the merits of cooperative notetaking during computer delivered instruction. Is cooperative notetaking beneficial to those involved? Is it most successful when notetaking is viewed as a process, a product, or a combination of both? What are problems that arise with this method? Are notes recorded with pencil and paper or on-line prove most beneficial? Do cooperative groups encourage learners to generate paraphrased notes?

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